



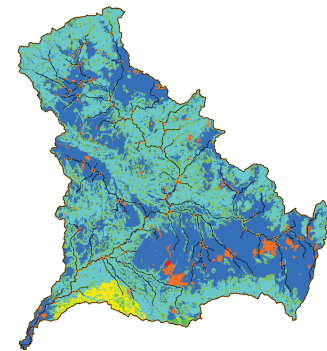
US Army Corps
of Engineers®

Analysis of SURRGO Data and Obtaining Soil Texture Classifications for Simulating Hydrologic Processes

by W. Clay LaHatte and Nawa Raj Pradhan

PURPOSE: This Coastal and Hydraulics Engineering Technical Note (CHETN) describes a method using the U.S. Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS), Soil Survey Geographic (SSURGO) (USDA 2016a) soils database and Geographic Information System (GIS) to obtain the soil texture classifications from SSURGO tabular data and add them to the spatial soils data.

BACKGROUND: When simulating surface runoff, many hydrology models allow for the inclusion of infiltration as a component of the simulation. In the real world, the amount of surface water that can infiltrate is a function of the properties of the soils in the area being considered. When simulating infiltration, these properties are described with several parameters (Figure 1), and the appropriate value ranges of those parameters are determined by the characteristics of the specific soil of interest and its soil texture classification. The soil texture classifications needed to help determine these parameter values are included in the SSURGO database.



Example of a GIS raster of
soil types covering a basin.

Infiltration									
ID	1	2	3	4	5	6	7	8	9
Description1	gullied-land-silt-loam-15%	gullied-land-sand-1%	water-.3%	pasture-clay-loam-3.5%	cotton-clay-loam-5%	pine-clay-loam-10%	pine-silt-loam-17%	cotton-silt-loam-9%	pasture-silt-loam-39%
Description2									
Hydraulic conductivity (cm/hr)	1.448195	1.410000	0.003000	0.188941	0.182522	0.109932	0.228412	1.633427	0.163479
Capillary head (cm)	16.680000	4.950000	0.003000	20.880000	20.880000	20.880000	16.680000	16.680000	16.680000
Porosity (m ³ /m ³)	0.486000	0.437000	0.582000	0.464000	0.464000	0.464000	0.486000	0.486000	0.486000
Pore distribution index (cm/cm)	0.234000	0.694000	0.001000	0.242000	0.242000	0.242000	0.234000	0.234000	0.234000
Residual saturation (m ³ /m ³)	0.015000	0.020000	0.015000	0.075000	0.075000	0.075000	0.015000	0.015000	0.015000
Field capacity (m ³ /m ³)	0.330000	0.091000	0.436500	0.318000	0.318000	0.318000	0.330000	0.330000	0.330000
Wilting point (m ³ /m ³)	0.133300	0.033000	0.133300	0.133300	0.133300	0.133300	0.197000	0.133000	0.133000

Figure 1. Example of infiltration parameters.

Problem identification. The SSURGO spatial data is provided via GIS shapefiles. These shapefiles do not presently include soil texture classification (silt, silt loam, clay, etc.) as an attribute. Some numerical models, like Gridded Surface Subsurface Hydrologic Analysis (GSSHA), need the soil texture classification that corresponds to particular cells or areas that the model is dealing with, but there is not a simple, direct way to relate the soil texture classification, embedded within the SSURGO database, to the spatial soil data coverage.

Soil texture classification. Soil textures range from dense clays to fine silts to loose sands. Soil textures have been classified into broad, general categories based on the percentage of sand, silt, and clay in the soil. The USDA Soil Texture Triangle was developed to aid in determining soil texture classifications (Figure 2). These classifications are included in the SSURGO database and after being associated with spatial soils data, can be used to assign infiltration parameters in several distributed hydrologic modeling applications.

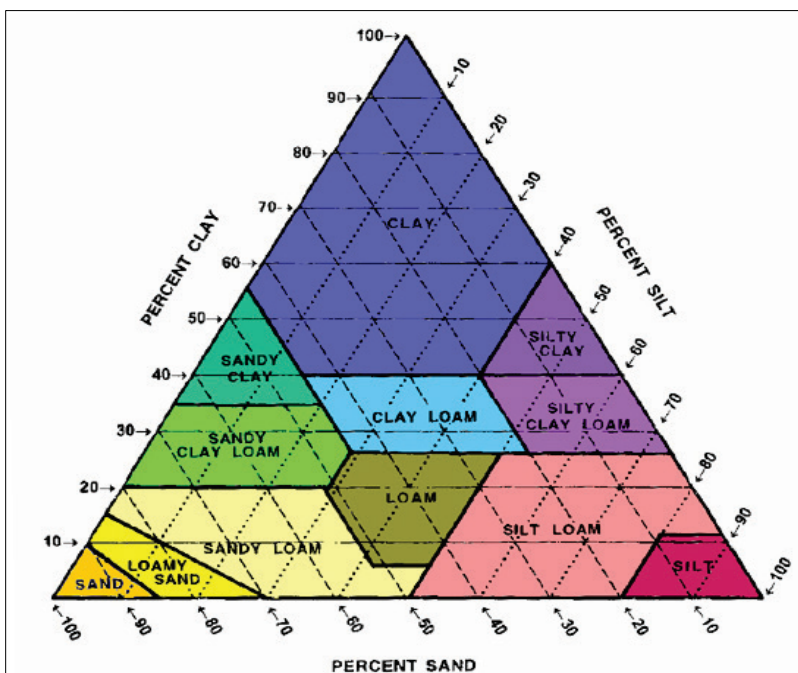


Figure 2. USDA soil texture triangle.

METHODS: The software tools needed for this procedure are the Environmental Systems Research Institute (ESRI) ArcMap (or equivalent) (ESRI 2011) and Microsoft Access (or equivalent).

Associating soil texture classifications from SSURGO data with the spatial data.

Adding soil texture classification to a SSURGO spatial data shapefile follows these 6 primary steps:

1. Download the SSURGO soil data of interest from the National Resources Conservation Service (NRCS), Web Soil Survey (USDA 2016b)(<http://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx>). The data package should contain the spatial data as shapefiles, tabular data as text files, and the soils template database (be sure this option is selected at download time) as a Microsoft Access database file (.mdb).
2. Open the database template in Access. The template contains a macro that will import the tabular data. *Note: If security settings are active in Microsoft Access, you may need to click the "Enable Content" button on the security bar.* Provide the full directory path to the folder containing the tabular data. The macro will import the data to fill the database tables.

3. In ArcMap, load the spatial soil data (shapefile) by adding to the data frame the file named soilmu_a_xx####.shp, where xx#### is the two-character state and the location designation (Example: soilmu_a_nc133.shp). *Note: If there is no projection file (.prj) included with the soils shapefile set, make sure that the coordinate system of the ArcMap data frame matches that of the soils shapefile before loading the shapefile (possibly GCS_North_American_1983). See the metadata included with the data package.*
4. The SSURGO spatial data shapefiles do not include soil texture classification as an attribute (Figure 3). The soil texture classification can be added to the spatial data shapefile attributes by *joining* the SSURGO tabular and spatial data. There are four joining steps needed to accomplish this. *Note: An optional fifth step can be performed if a Unified Classification attribute is desired.* Each join adds additional fields to the list of related attributes for the soils shapefile. These attributes will not become permanent until the shapefile is exported and saved as a new shapefile (described below). Table 1 provides the SSURGO database tables and keys needed to add the soil texture classifications to the spatial data. If, additionally, the Unified Classification attribute is desired, step 5 in Table 1 provides the database table join information to obtain this.

FID	Shape	AREASymbol	SPATIALVER	MUSYM	MUKEY
0	Polygon	NC133	5	NeE	116091
1	Polygon	NC133	5	Wo	116108
2	Polygon	NC133	5	Pa	116097
3	Polygon	NC133	5	KuB	116082
4	Polygon	NC133	5	To	116102
5	Polygon	NC133	5	Pt	116099
6	Polygon	NC133	5	Ln	116085
7	Polygon	NC133	5	Mk	116089
8	Polygon	NC133	5	Mk	116089
9	Polygon	NC133	5	St	116101

Figure 3. The spatial soils data attribute table prior to joining with the tabular data.

Table 1. SSURGO soils database tables and key fields used for joining spatial and tabular soils data to add soil texture classifications to the spatial data.

Join Step	SSURGO Table	Key Field	Field Name
1	component	mukey	Map Unit Key
2	chorizon	cokey	Component Key
3	chtexturegrp	chkey	Chorizon Key
4	chtexture	chtgkey	Chorizon Texture Group Key
5*	chunified	chkey	Chorizon Key

* Optional; can be used if Unified Classification is desired.

Right-click the soils spatial shapefile in the ArcMap Table of Contents, and under the “Joins and Relates” sub-menu, choose “Join...”

For each of the four (or optional five) necessary join operation, follow these steps:

- a. Choose the appropriate key field for the join (see Table 1). For example, for the first join, the table is “component” and the key field is “mukey.”
- b. Navigate to the folder where the Soils Database is located, select the database file, and then select the appropriate SSURGO database table (Figure 4) as presented in Table 1.

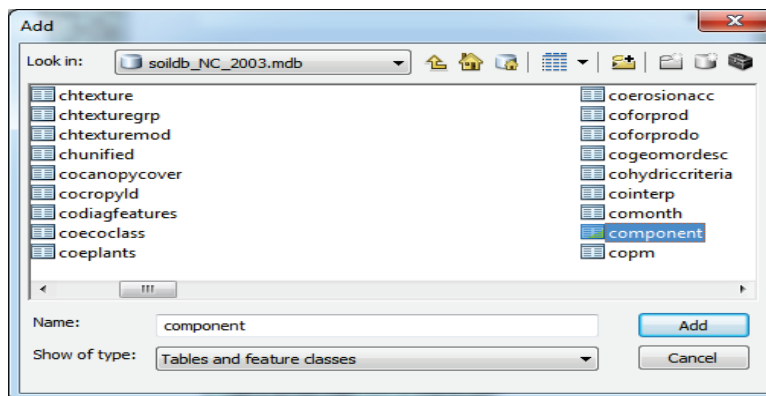


Figure 4. System dialog for selecting the database table.

- c. Choose the appropriate key field (Figure 5) (see Table 1). *Note: It has been observed that in order for the join to work properly, it may be necessary to actually open the dropdown list for “the field in the table to base the join on” and click on the appropriate key value, even if it is already highlighted.*

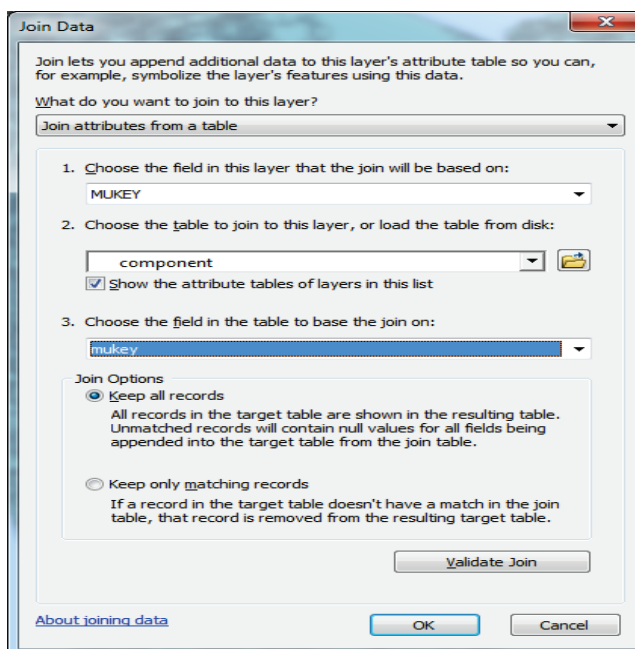


Figure 5. The Join Data dialog box, where key database fields for joining to a table are specified.

- d. Click “OK” to perform the join operation. The attribute table for the soils shapefile should now have additional fields with values as provided from the database (Figure 6). *Note: There may be some null values, but if all the additional fields contain null values then there was a problem making the join. If so, verify that the correct database has been used and that the database table contains the information expected from the tabular data.*

FID	Shape	AREASymbol	SPATIALVER	MUSYM	MUKEY	compptct_l	compptct_r	compptct_h	compname	compkind	majcr
0	Polygon	NC133	5	NeE	116091	<Null>	50	<Null>	Newhan	Series	Yes
1	Polygon	NC133	5	Wo	116108	<Null>	80	<Null>	Woodington	Series	Yes
2	Polygon	NC133	5	Pa	116097	<Null>	85	<Null>	Pactolus	Series	Yes
3	Polygon	NC133	5	KuB	116082	<Null>	2	<Null>	Murville	Series	No
4	Polygon	NC133	5	To	116102	<Null>	10	<Null>	Torhunta	Series	Yes
5	Polygon	NC133	5	Pt	116099	<Null>	100	<Null>	Pits	Miscellaneous	Yes
6	Polygon	NC133	5	Ln	116085	<Null>	5	<Null>	Murville	Series	No
7	Polygon	NC133	5	Mk	116089	<Null>	80	<Null>	Muckalee	Series	Yes
8	Polygon	NC133	5	Mk	116089	<Null>	80	<Null>	Mucclalee	Series	Yes

Figure 6. Part of the spatial soils data attribute table after the first join with the tabular data.

5. After all four join operations have been completed successfully, right-click the soils shapefile and choose “Data,” then “Export Data...” Export “All features,” select the coordinate system to be saved with the new shapefile, and specify the folder and name for the new shapefile. The new shapefile will contain all of the joined data fields as attributes.
6. To remove the unwanted fields from the shapefile feature attributes and leave only the fields pertinent to the soils texture classification, follow these steps:
 - a. Select the “Delete Field” tool from the ArcMap toolbox under “Data Management Tools,” then under “Fields.”
 - b. Add the spatial soils data shapefile as the “Input Table.”
 - c. Select all the fields with “Select All.”
 - d. Deselect the following fields: AREASymbol, SPATIALVER, MUSYM, MUKEY, and from near the end of the field list, “texture,” “texdesc,” and “texcl.”
 - e. Click “OK.”

If there are multiple soils shapefiles used to cover additional regions of the study domain, repeat the operations in steps 1 through 6 to join the corresponding tabular data (imported to a soils database) to each shapefile. Then, merge all the shapefiles using the “Merge” tool found in the ArcMap toolbox under “Data Management Tools,” “General.” *Note: The fields in each of the shapefiles should be the same. If the list of fields under “Field Map” in the Merge tool shows the attribute field names more than once, then something may be missing from one or more of the data sets, and the join operations may need to be repeated.*

After completing these steps, there should be a new soils shapefile that contains attributes that include the soil texture classification.

Assigning identification (ID) values to soil texture classifications. If it is desired to associate an ID value with each soil texture classification, as for use with a soil texture raster for

example, those can be assigned manually by the user as an additional attribute and can be any values that make sense for the application. Table 2 contains the SSURGO Soil Texture Classifications and optional texture ID numbers that can be used as soils raster values.

Table 2. SSURGO soil texture classifications.

TEXTURE ID (Suggested)	Texture	Texture Classification (texcl)
1	C	Clay
2	CL	Clay loam
3	COS	Coarse sand
4	COSL	Coarse sandy loam
5	FS	Fine sand
6	FSL	Fine sandy loam
7	L	Loam
8	LCOS	Loamy coarse sand
9	LFS	Loamy fine sand
10	LS	Loamy sand
11	LVFS	Loamy very fine sand
12	S	Sand
13	SC	Sandy clay
14	SCL	Sandy clay loam
15	SL	Sandy loam
16	SI	Silt
17	SIL	Silt loam
18	SIC	Silty clay
19	SICL	Silty clay loam
20	VFS	Very fine sand
21	VFSL	Very fine sandy loam

Handling regions having null soil texture classification. There may be instances where some SSURGO soil areas do not have an assigned soil texture classification, and “Null” will appear as the value in the texture classification field. In these cases, a classification can be provided manually.

There are two ways discussed below by which to accomplish a manually determined soil classification. These two options are to make use of the following:

1. The particle size information from the SSURGO database—The use of the particle size information requires making a judgement about the information provided and how that relates to the general texture classifications.
2. Another source for soil information, such as the Food and Agriculture Organization of the United Nations (FAO) soils dataset—To use the FAO soils dataset requires making use of the soil texture triangle to make a classification determination.

One way to obtain a reasonable value is to reference other fields in the attributes that may contain information. The *taxpartsiz* field, for example, may sometimes contain information when the texture classification field does not. The *taxpartsiz* field provides a description of the dominant grain size, such as “fine,” “coarse loamy,” etc. This information can be used to help estimate a soil texture classification.

Another way to obtain a reasonable value is to use another soils dataset that contains soil properties for the areas of interest, such as the Digital Soil Map of the World provided by the FAO (<http://www.fao.org/geonetwork/srv/en/metadata.show?id=14116&currTab=distribution>)

and <http://www.fao.org/soils-portal/soil-survey/soil-maps-and-databases/faounesco-soil-map-of-the-world/en/>). The FAO data attributes include the percent of sand, silt, and clay in the *SU_Info.xls* spreadsheet file.

Obtaining information from the FAO dataset. The FAO dataset includes attributes for percent sand, silt, and clay. Using these values along with the Soil Texture Triangle above, an estimated soil texture classification can be determined. By placing the spatial soils data from both SSURGO and the FAO into the GIS, a determination can be made as to which soil classification to use in place of the null values in the SSURGO dataset.

Example: As depicted in Figure 7, the spatial SSURGO soils data, in green, is displayed on top of the FAO soils data, in yellow. The attributes for the FAO data are displayed for the selected polygon. The attribute of interest here is the dominant soil (DOMSOI). Here, the soil unit symbol value is Cl (CL). To get the percentage of sand, silt, and clay for this area, view the contents of the Microsoft Excel spreadsheet file included with the DMSW dataset called *Generalized_SU_Info.xls*. In this spreadsheet, find the row which contains the soil unit symbol that matches the dominant soil type from the FAO spatial data. In this example case, the soil unit symbol “CL” contains in the topsoil percentages of sand, silt, and clay of 46.3%, 24.9%, and 28.8%, respectively. Using these percentages with the Soil Texture Triangle above reveals a soil texture of “Sandy Clay Loam.” This texture classification can be added to the attribute table of the newly created shapefile from above by editing the shapefile in the GIS software.

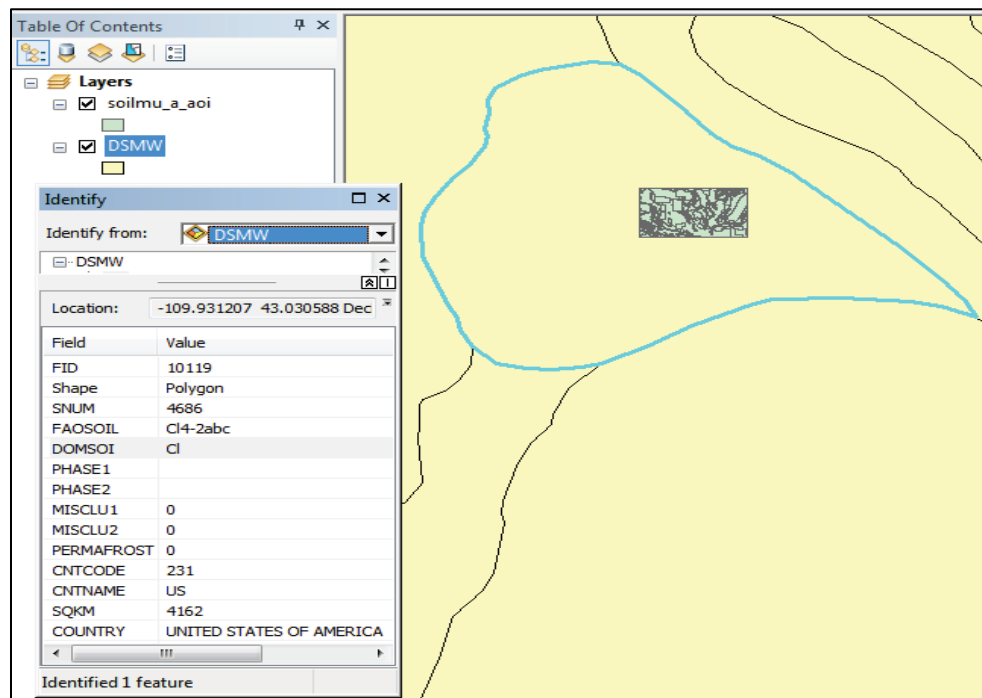


Figure 7. Example GIS window showing spatial SSURGO soils data on top of FAO soils data, along with the FAO soil attributes.

CONCLUSIONS: The procedure described in this CHETN can assist with obtaining soil textures and applying soil parameters for use in hydrologic modeling applications. The soil

texture map also has utility for majority of earth science studies such as agriculture, geology, geomorphology, engineering, biology, history, etc. (Soil Survey Division Staff 1993). The procedure pulls from the SSURGO collection database for a given region of interest. Once the procedure has been completed successfully, a soil coverage shapefile containing an attribute field for soil texture classification will have been produced.

POINT OF CONTACT: The point of contact for technical inquiries is Clay LaHatte (Clay.W.LaHatte@usace.army.mil). This technical note should be referenced as follows:

LaHatte, W. C., and N. R. Pradhan. *Analysis of SURRGO data and obtaining soil texture classifications for simulating hydrologic processes*. ERDC/CHL CHETN-X-3. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

An electronic copy of this CHETN is available from
<http://chl.erdcl.usace.army.mil/chetn>.

REFERENCES

- Aquaveo. 2015. *Watershed Modeling System: Release 10*. Provo, UT: Aquaveo.
- ESRI. 2011. *ArcGIS Desktop: Release 10.1*. Redlands, CA: Environmental Systems Research Institute.
- Soil Survey Division Staff. 1993. *Soil survey manual*. Soil Conservation Service. U.S. Department of Agriculture Handbook 18. Washington, DC: U.S. Department of Agriculture, Natural Resources Conservation Service.
- U.S. Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS). 2016a. Description of SSURGO Database. Accessed 8 April.
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/geo/?cid=nrcs142p2_053627
- U.S. Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS). 2016b. Web Soil Survey. Accessed 8 April.
<http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/survey/>

NOTE: *The contents of this technical note are not to be used for advertising, publication, or promotional purposes. Citation of trade names does not constitute an official endorsement or approval of the use of such products.*